

# Reanalysis at ECMWF

Dick Dee

ECMWF

[dick.dee@ecmwf.int](mailto:dick.dee@ecmwf.int)



# Reanalysis at ECMWF

Dick Dee

ECMWF

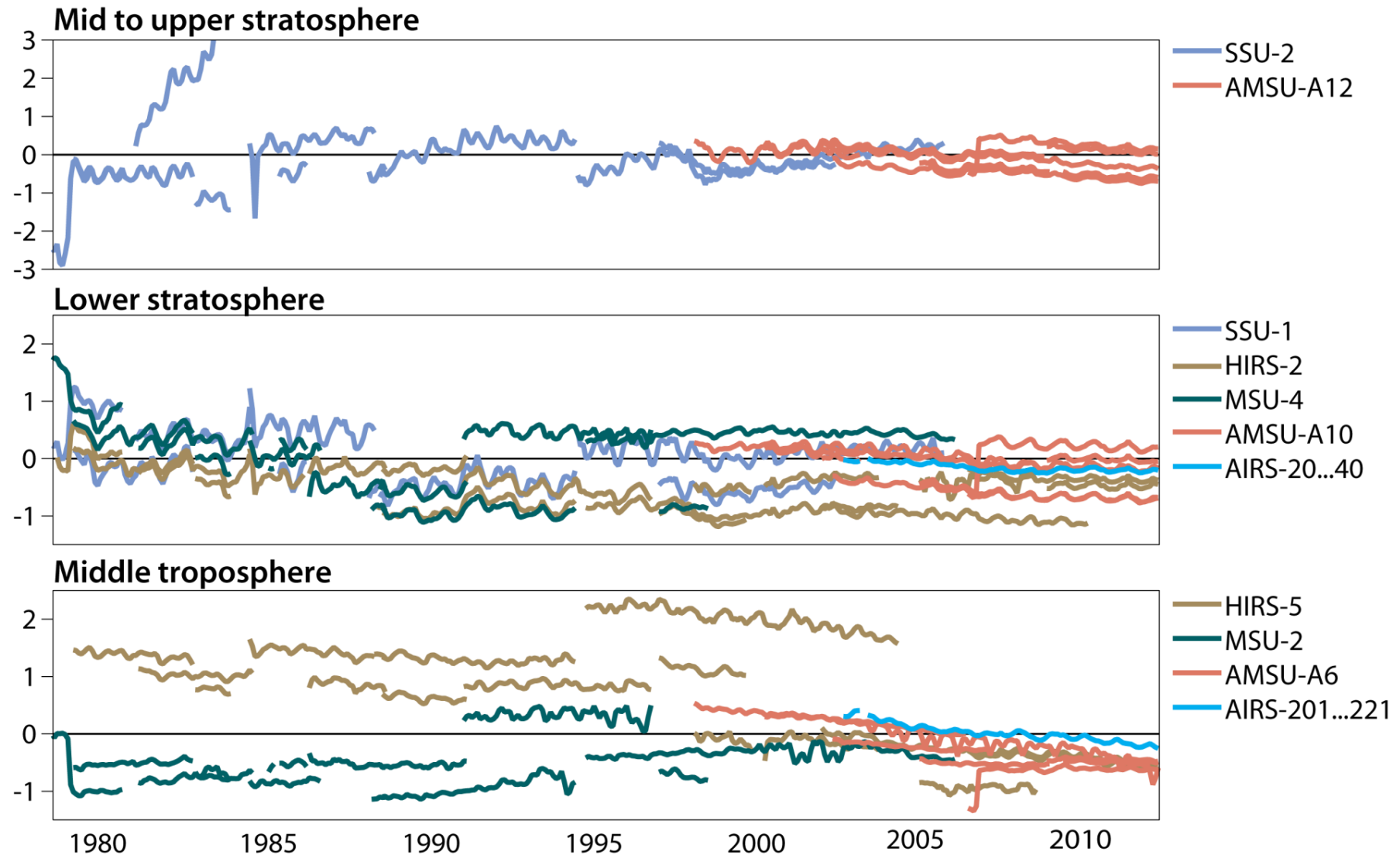
[dick.dee@ecmwf.int](mailto:dick.dee@ecmwf.int)

- Successor of ERA-Interim: ERA5
- ERA-CLIM/ERA-CLIM2 projects
- Implementation of Copernicus Services

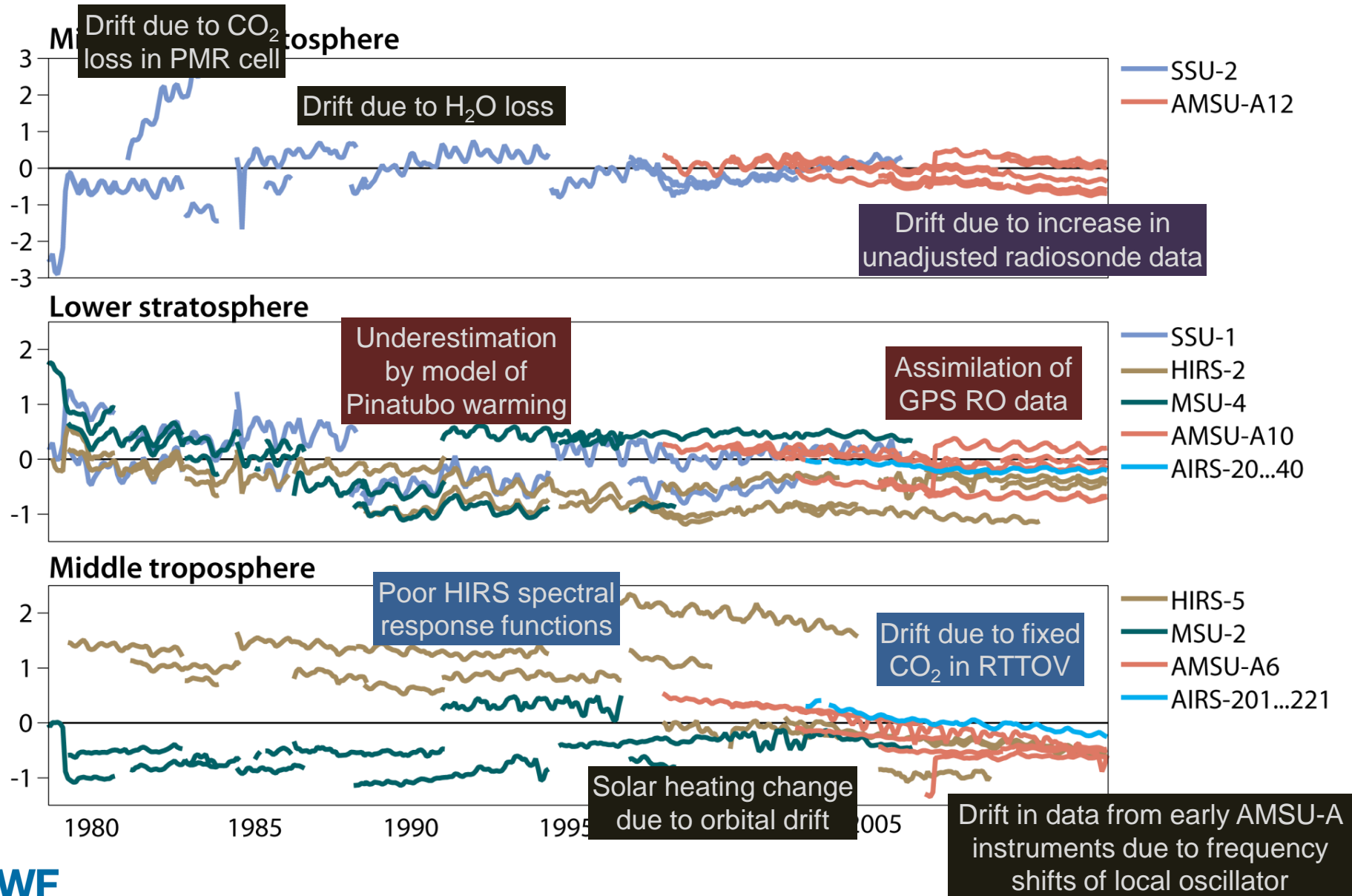
## ERA-Interim → ERA5

	ERA-Interim	ERA5
Start of production	August 2006 IFS Cy31r2	July 2015 IFS Cy41r2
Model boundary conditions	As used in forecasting ( <i>inconsistent SST</i> )	Appropriate for climate (CMIP5, HadISST2.1)
Spatial resolution	79 km global (T255) 60 levels to 10 Pa	31 km global (T639) 137 levels to 1 Pa
Time period	1979 - present	1979 - present (extension to ~1950)
Dissemination	Monthly	Monthly for ERA5; daily for ERA5T
Observations	Mostly ERA-40, GTS	Various reprocessed CDRs
Radiative transfer	RTTOV7	RTTOV11
Analysis method	4D-Var 1D+4DVar rain	10-member ensemble 4D-Var (EDA) All-sky MW
Variational bias corrections	Satellite radiances	Radiances, ozone, aircraft, surface pressure, radiosondes

# Bias adjustments in ERA-Interim: Lessons learned (*Simmons et al, QJ 2014*)



# Bias adjustments in ERA-Interim: Lessons learned (*Simmons et al, QJ 2014*)



## New input data sets for ERA5

METEOSAT AMV (EUMETSAT)  
GOES AMV (CIMSS 1995-2013)  
GMS and GOES-9 AMV (Japan)  
AVHRR NOAA AMV (CIMSS 1982-2010)  
AVHRR METOP AMV (EUMETSAT)

METEOSAT radiances (EUMETSAT)  
ASCAT L1 Sigma0 (EUMETSAT)  
SSM/I radiances (CM-SAF)

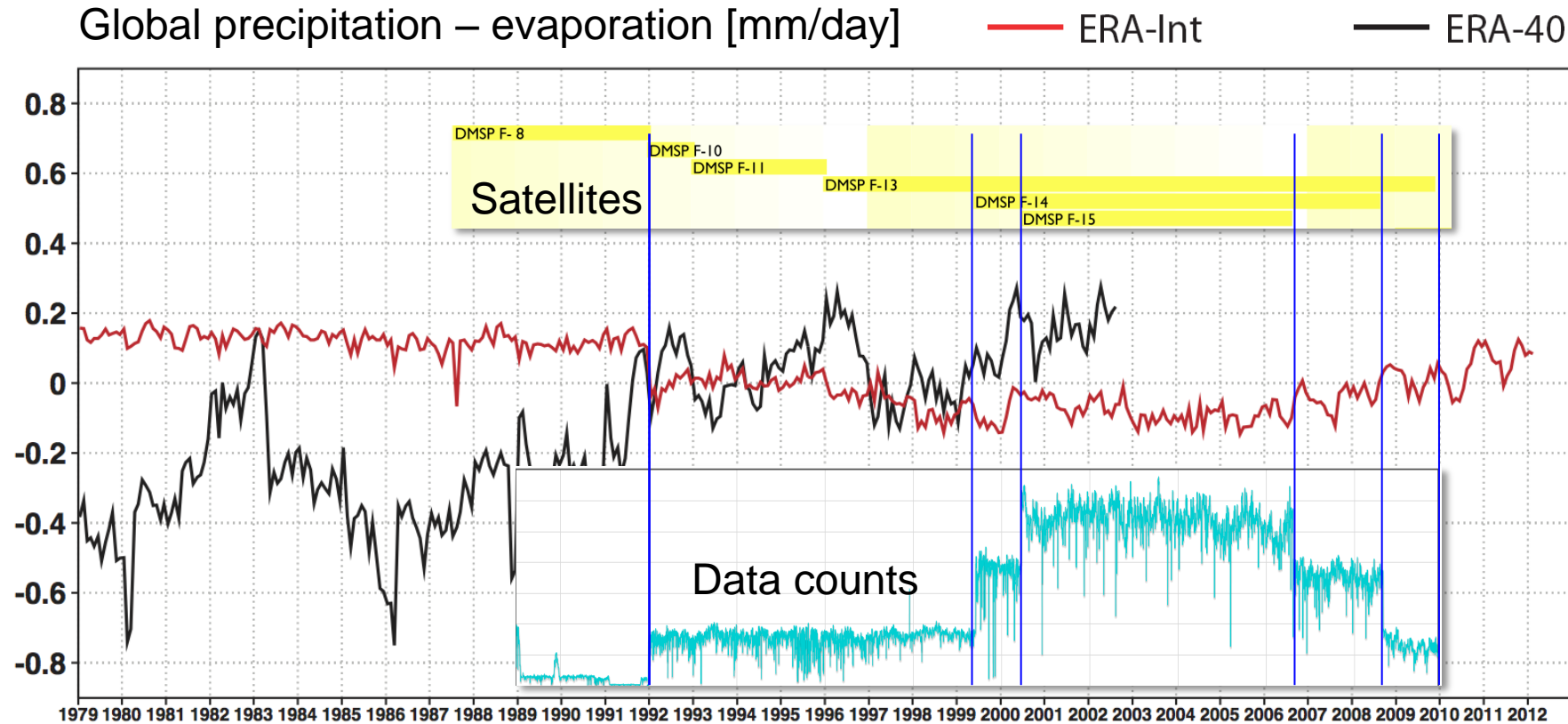
SBUV and TOMS ozone (NASA v8.6)

Upper-air in situ observations (NCAR DS 370.0)  
Surface pressures (ISPD 3.2.6)  
Marine surface reports (ICOADS 2.5.1)

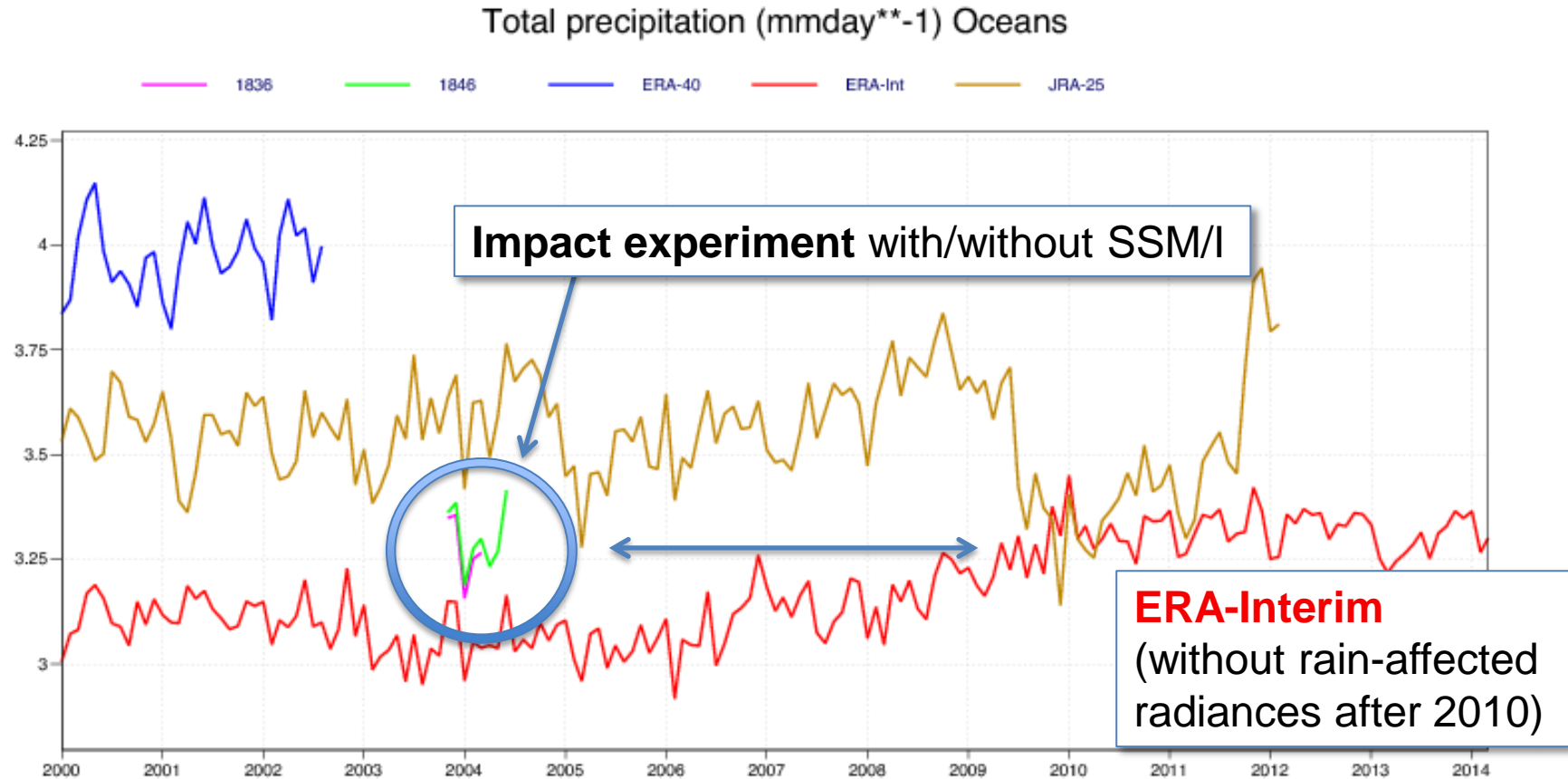
### Improved radiative transfer modelling:

- Microwave and infrared frequency shifts
- Time-varying SSU cell pressure
- Time-varying atmospheric CO2 concentration

# ERA-Interim: 4D+1D-Var assimilation of rain-affected SSM/I radiances



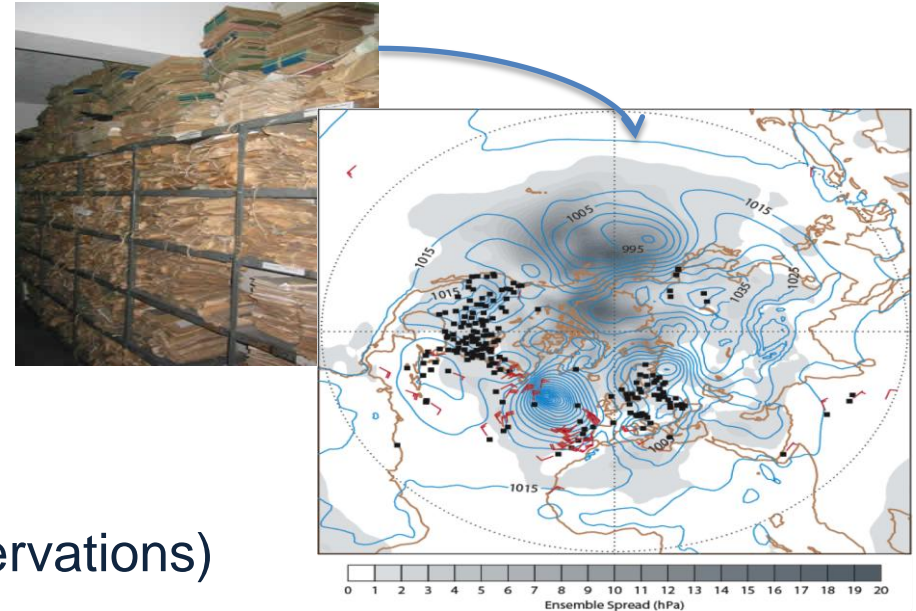
## ERA5: 4D-Var assimilation of all-sky SSM/I radiances





# The European ERA-CLIM project (2011-2013)

**Goal:** Preparing input observations, model data, and data assimilation systems for a global atmospheric reanalysis of the 20<sup>th</sup> century

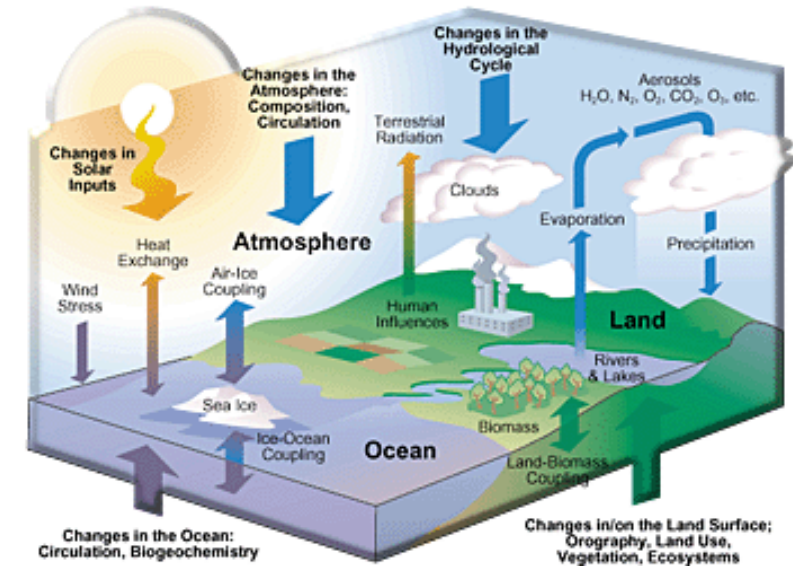


## Main components:

- Data rescue (in-situ upper-air and satellite observations)
- Incremental development of new 20C reanalysis products
- Use of reanalysis feedback to improve the historic data record
- Access to reanalysis data and observation quality information

# The European ERA-CLIM2 project (2014-2016)

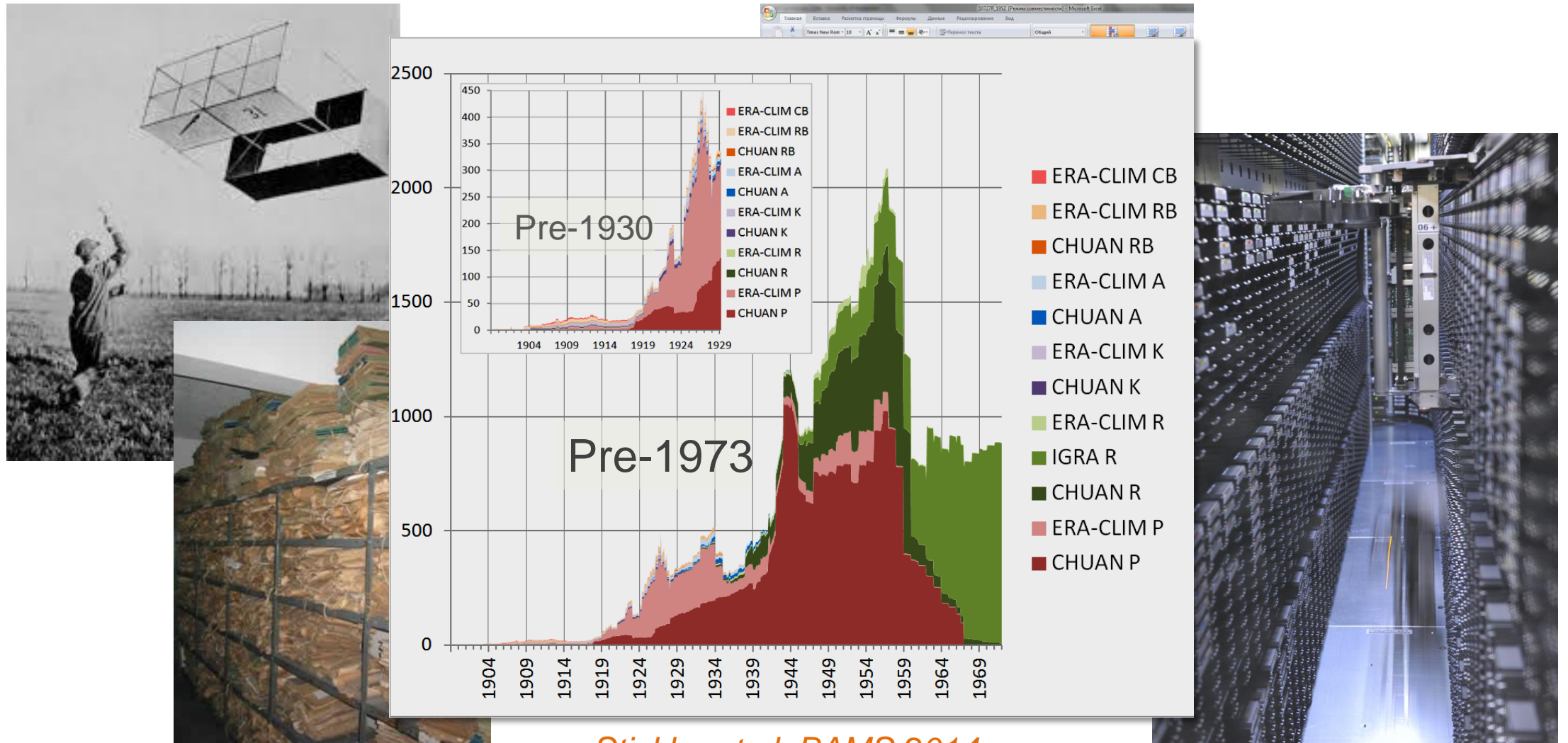
**Goal:** Production of a consistent 20<sup>th</sup>-century reanalysis of the coupled Earth-system:  
*atmosphere, land surface, ocean, sea-ice,*  
*and the carbon cycle*



## Main components:

- Production of coupled reanalyses, for 20C and the modern era
- Research and development in coupled data assimilation
- Earth system observations for extended climate reanalyses
- Evaluation of uncertainties in observations and reanalyses

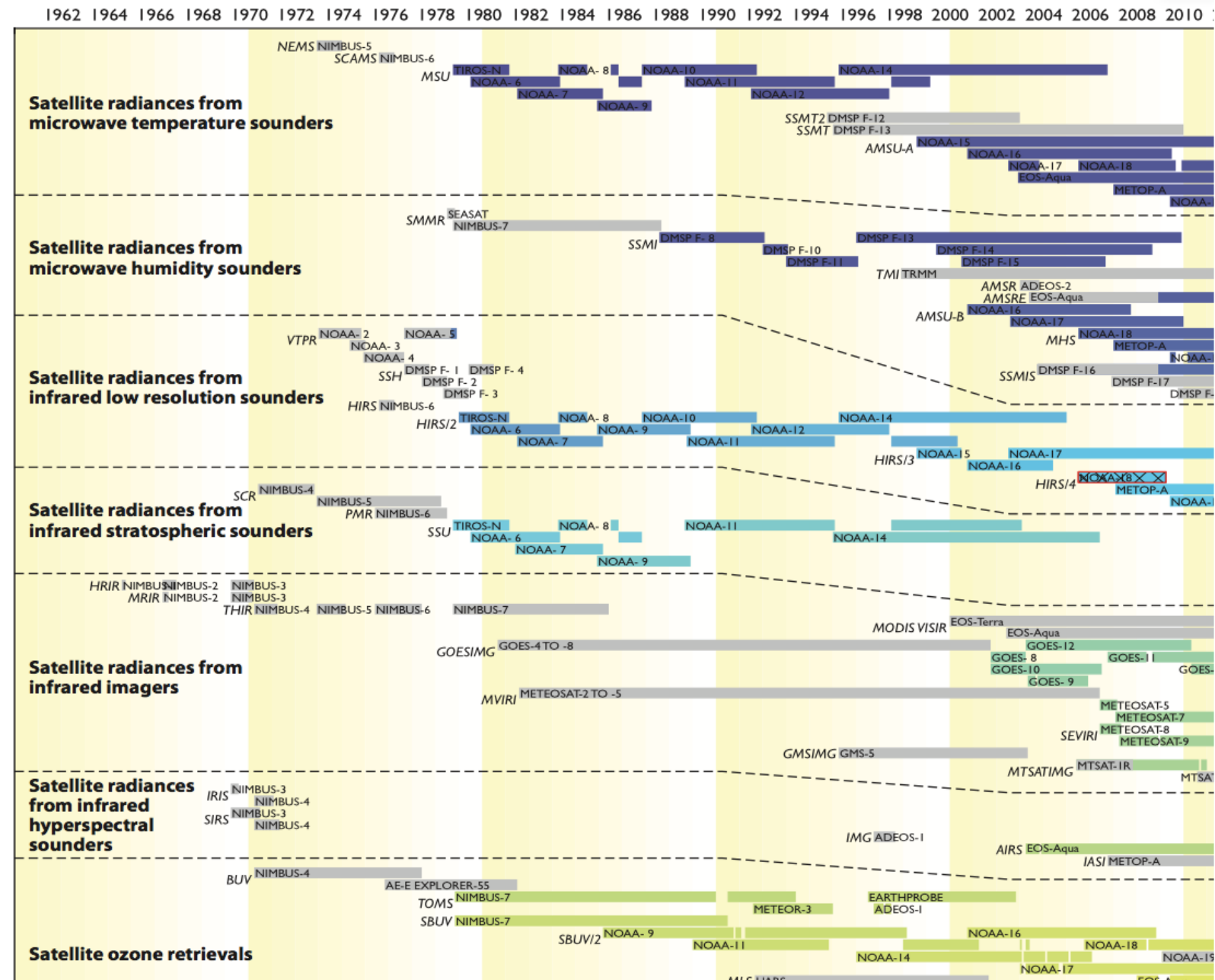
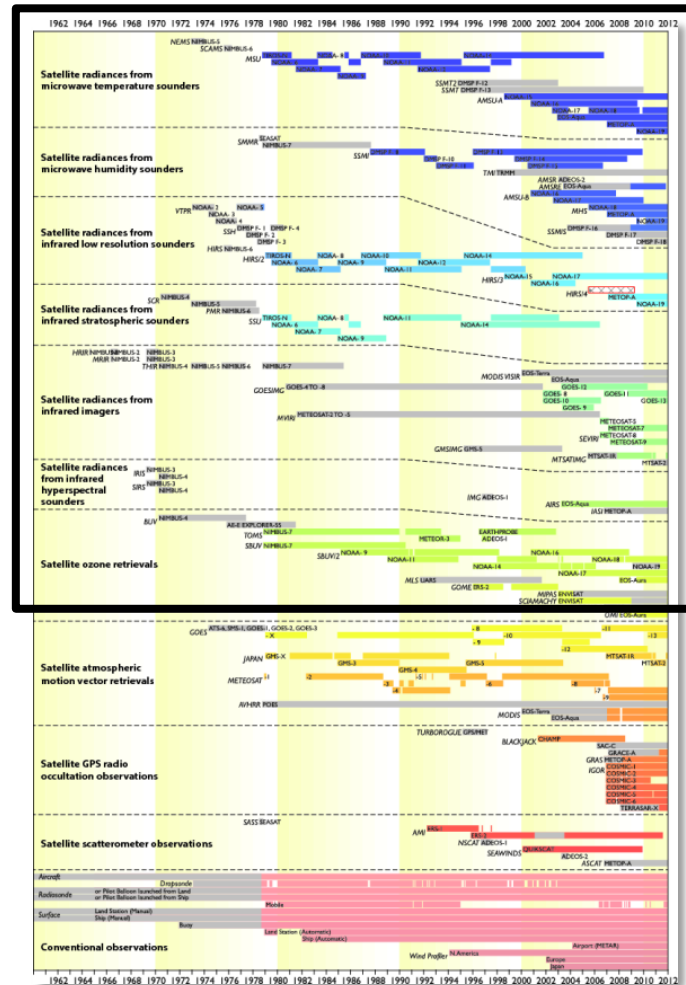
# Data rescue: Early 20<sup>th</sup>-century upper-air weather observations



*Stickler et al, BAMS 2014*

# Satellite data rescue

*Poli et al 2015*





# NIMBUS-4

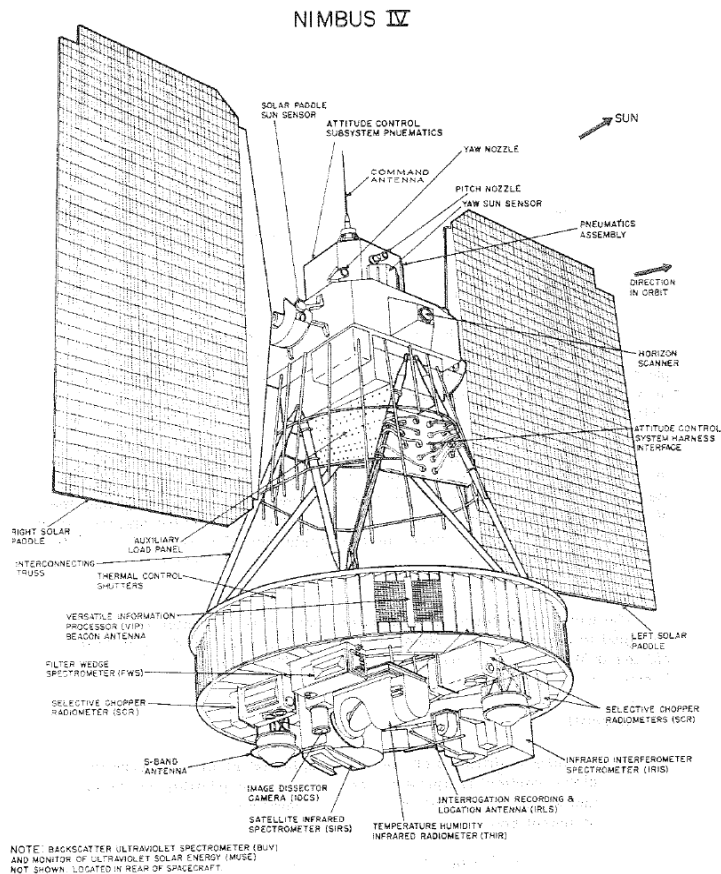


Figure 1-1. Basic Configuration of Spacecraft

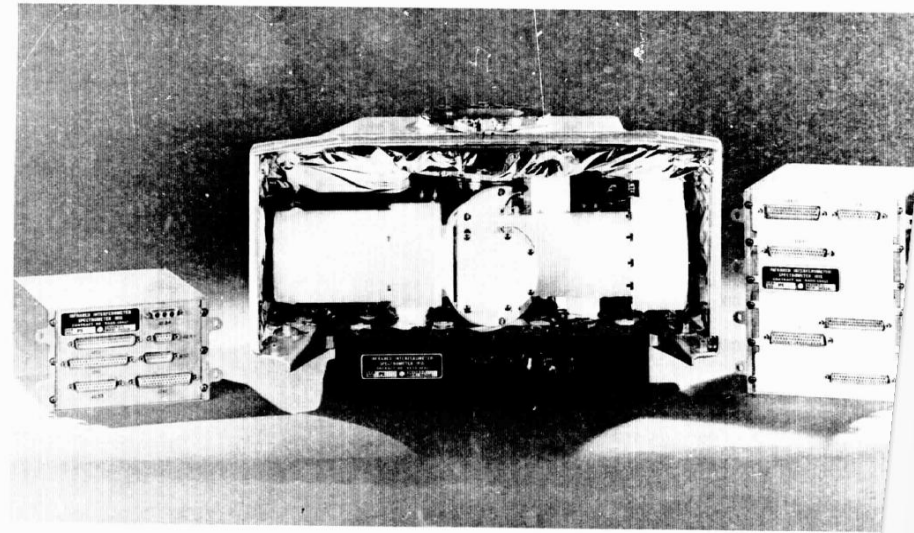
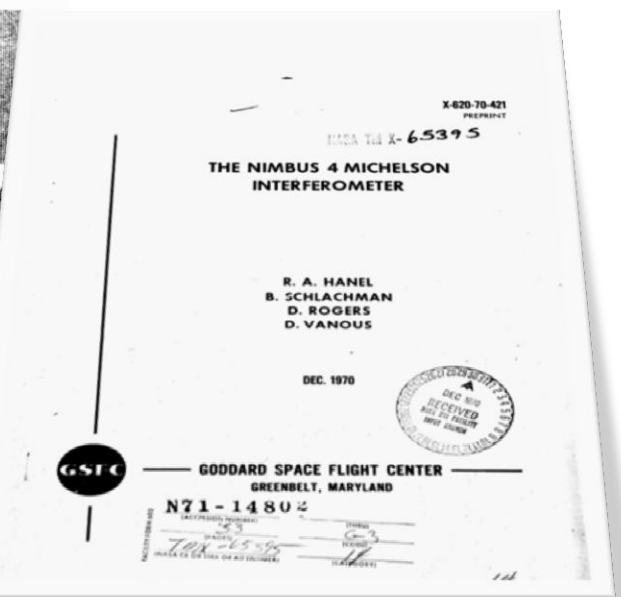


Figure 1. The infrared interferometer (IRIS-D) on Nimbus 4 consists of an optical module, shown enclosed by a thermal shroud in the center of the figure, and of two modules which contain electronic circuitry. The optical module is mounted below a sensory ring (not shown), so that the port visible on top of the shroud views earth. The electronic modules fit into compartments within the sensory ring. The maximum dimension of the shroud across the exposed opening is 44 cm.



Many scanned documents are available on the internet, including recent studies: *Harries et al. (Nature 2001)*, *Jiang et al. (Proc. SPIE 2011)*

Data have been recovered from ageing tape media by NASA, and are now available on the NSSDC website at <http://nssdc.gsfc.nasa.gov>

## ERA-CLIM global reanalysis products

### Atmospheric reanalysis for the 20<sup>th</sup>-century (1900-2010)

Using an ensemble of 10 plausible SST/sea-ice evolutions

Assimilating observations of surface pressure and marine wind

125 km global resolution, 91 vertical model levels

**ERA-20CM**

Ensemble of model integrations  
*(mainly monthly products)*

IFS Cy38r1 + CMIP5 data +  
HadISST v2.1

**ERA-20C  
+ OFA**

Assimilation of surface observations  
*(3-hourly products)*

+ ICOADS v2.5.1 +  
ISPD v3.2.6 *(incl. ERA-CLIM)*

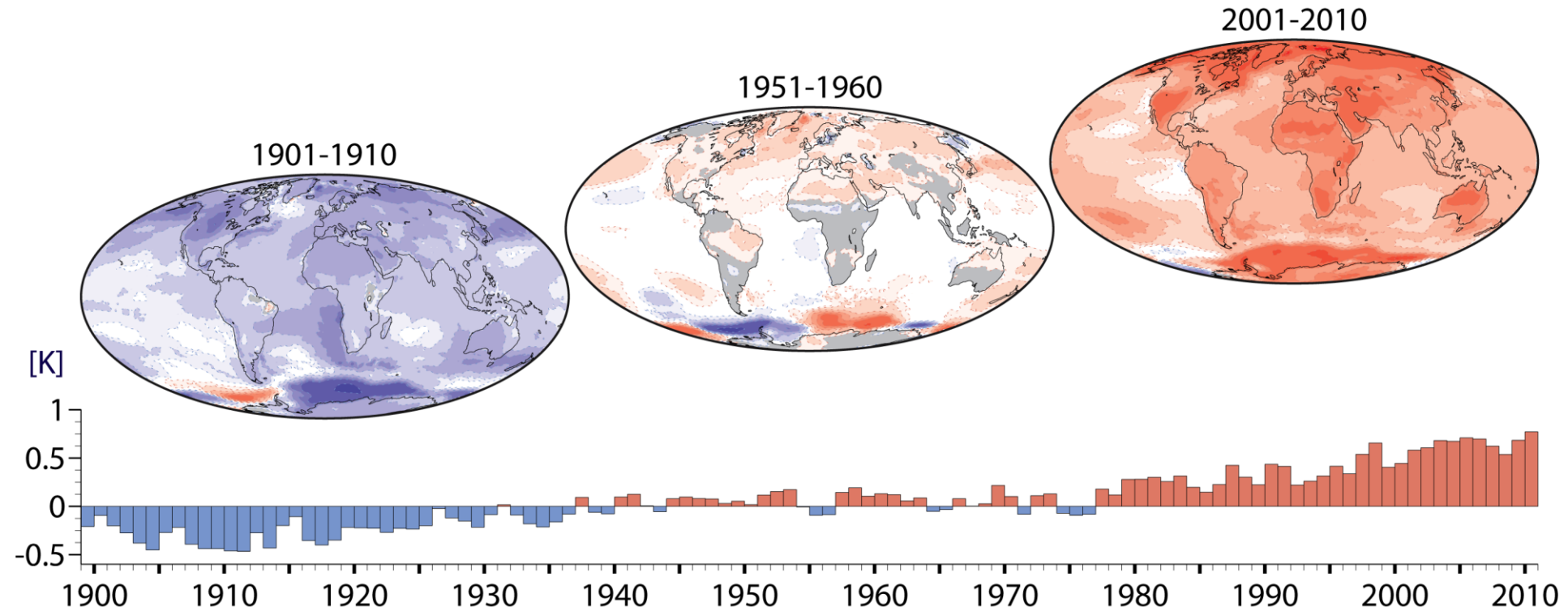
**ERA-20CL**

High-resolution land surface  
*(25km global)*

+ CHTESSEL

*Final ERA-20C/M/L datasets (~200 Tb) will be available at  
<http://www.ecmwf.int/en/research>*

# ERA-20CM: Annual and decadal temperature change (ensemble mean)



ERA-20CM data available at [www.ecmwf.int/research](http://www.ecmwf.int/research)

*Hersbach et al, QJ 2015*

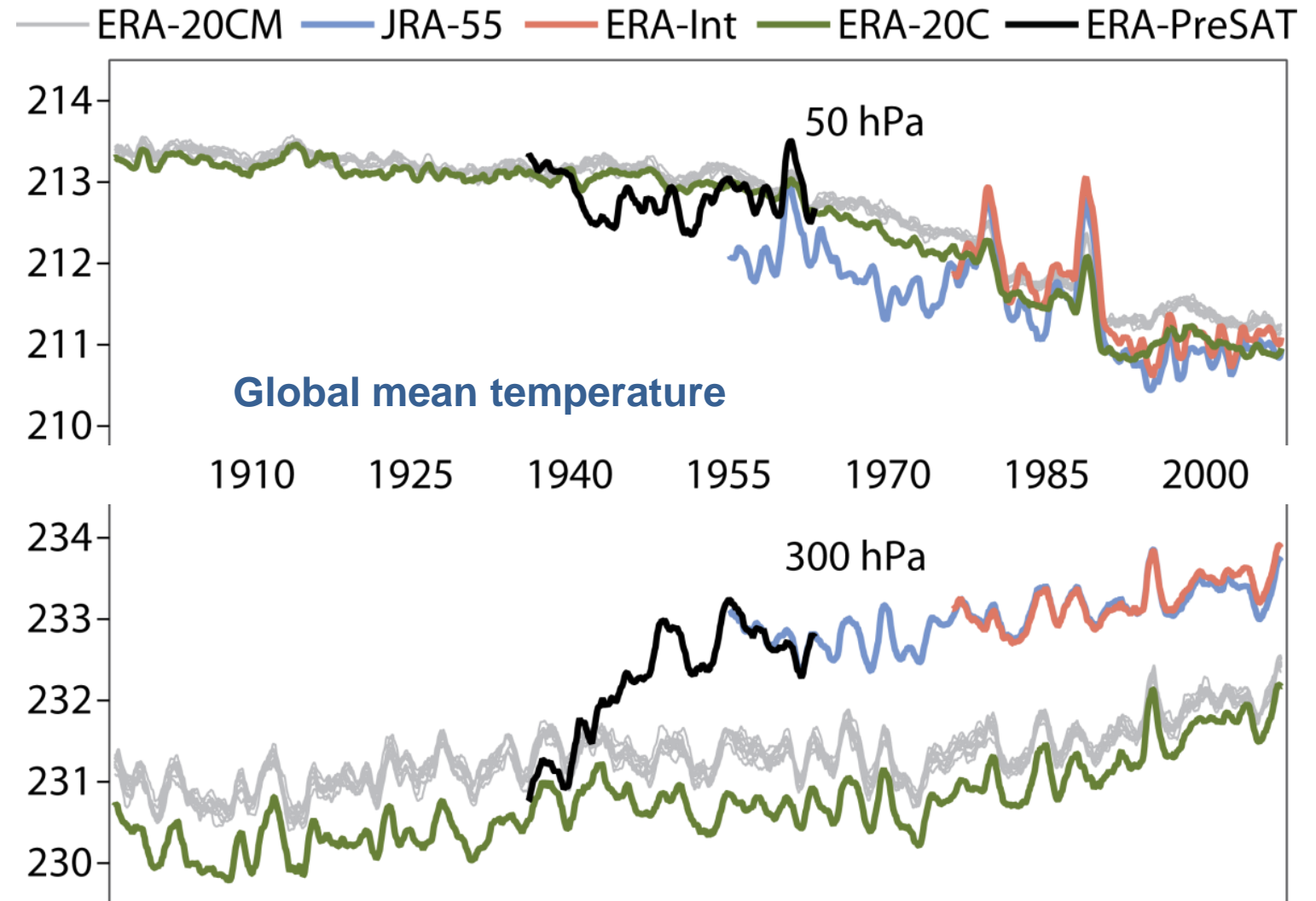
# ERA-20C and experiments with ERA-CLIM2 upper-air observations

ERA-20CM trends seem OK

ERA-20C trends are too strong

Model is biased cold in troposphere

Impact of radiosondes becomes substantial after ~1948

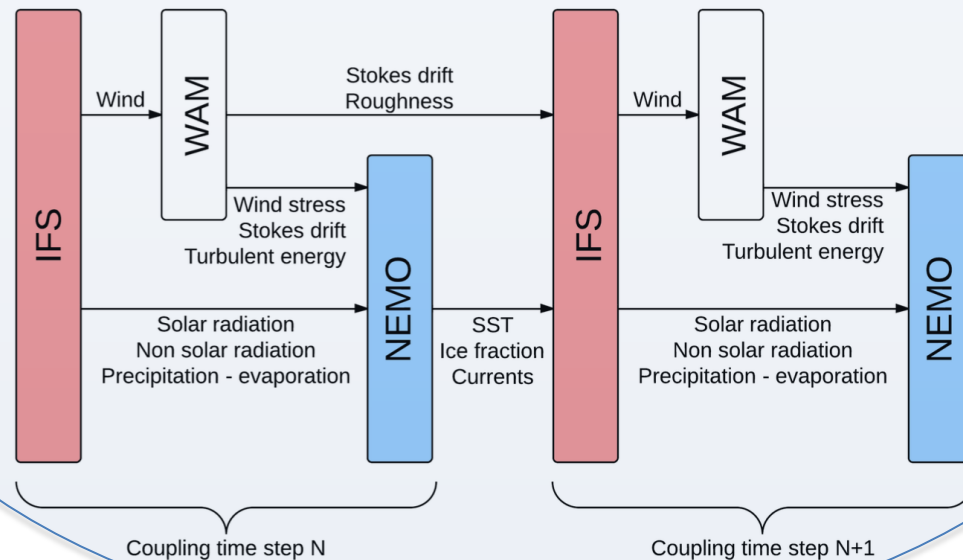




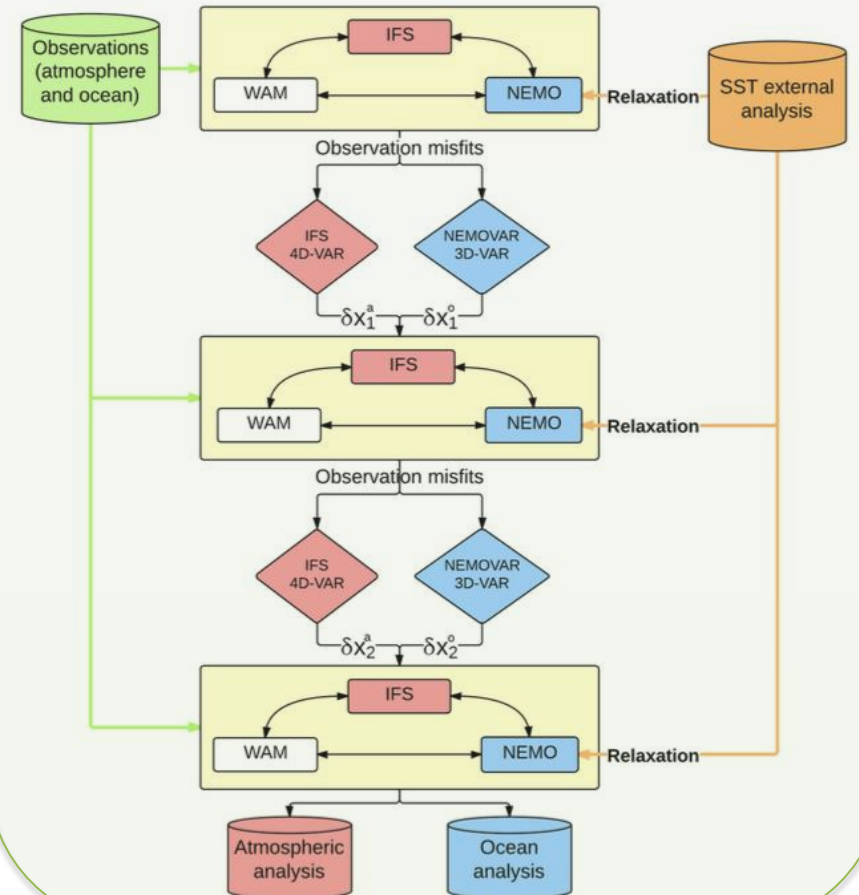
# CERA: A coupled data assimilation system for climate reanalysis

*Laloyaux et al 2015a*

ECMWF's coupled IFS/NEMO model used for seasonal prediction



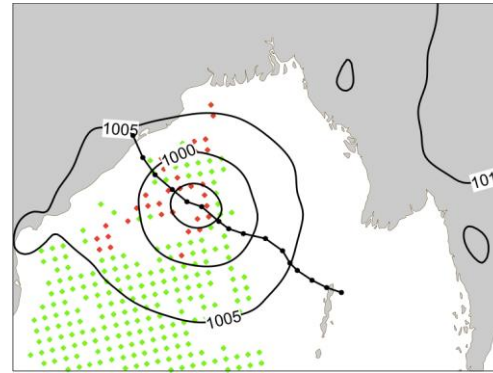
Incremental 4D-Var for coupled data assimilation



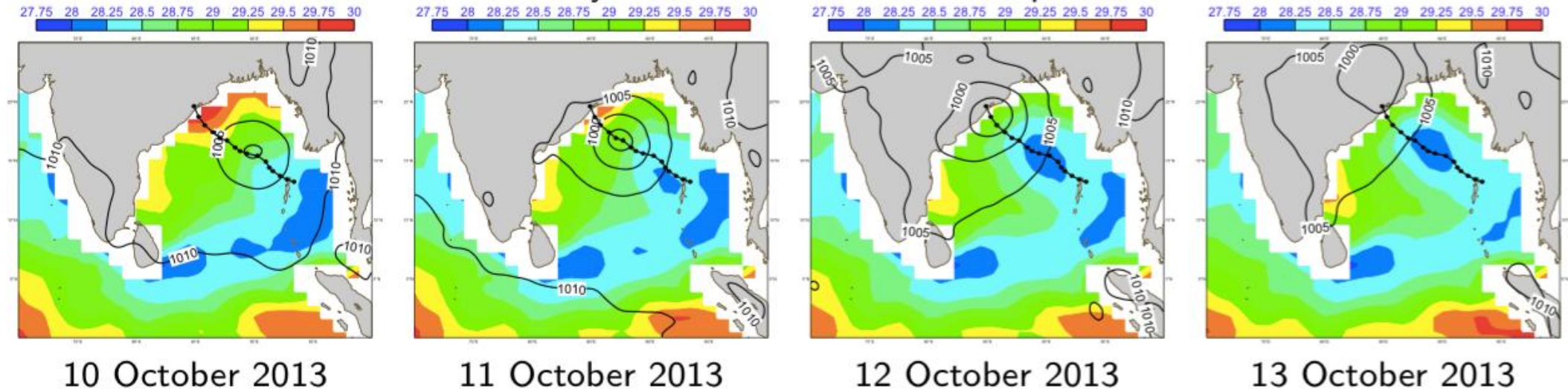
# CERA: A case study

- Tropical Cyclone Phailin
- Assimilation of scatterometer wind data

*Laloyaux et al 2015b*



CERA analysis of the Sea Surface Temperature



## *Long-term goals for climate reanalysis:*

- Physically plausible representation of the sea surface even if unobserved
- Consistent fluxes at the atmosphere-ocean interface; improved energy budgets

# Current plan for reanalysis productions at ECMWF

